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DESCRIPTION

CIRCULARLY POLARIZING PLATE, OPTICAL FILM AND IMAGE DISPLAY

Technical Field

[0001]

The invention relates to a circularly polarizing plate. The invention also relates to an optical film using the circularly polarizing plate. The invention further relates to image displays, such as liquid crystal displays, organic EL displays, CRTs, and PDPs, using the circularly polarizing plate or the optical film.

Background Art

[0002]

Liquid crystal display are rapidly developing in market, such as in clocks and watches, cellular phones, PDAs, notebook-sized personal computers, and monitor for personal computers, DVD players, TVs, etc. In the liquid crystal display, visualization is realized based on a variation of polarization state by switching of a liquid crystal, where polarizers are used based on a display principle thereof. Particularly, usage for TV etc. increasingly requires display with high luminance and high contrast, polarizers having higher brightness (high transmittance) and higher contrast (high polarization degree) are being developed and introduced.

[0003]

Circularly polarizing plates are used as antireflection filters for liquid crystal displays and various types of displays. Particularly in terms of brightness enhancement, the use of circularly polarizing plates shows great promise for a liquid crystal mode using multidomain alignment. Such circularly polarizing plates are generally formed by laminating a dichroic absorbing linearly-polarizing plate and a quarter wavelength plate in such a manner that their optical axes intersect at an angle of 45° or 135°. For example, a stretched film is used as the quarter wavelength plate. Due to dispersion in which refractive index generally varies with wavelength, the retardation of such a stretched film can be just a quarter of a specific wavelength but can deviate from a quarter of any other wavelength. Thus, a single piece of such a stretched film cannot function as a quarter wavelength plate in a broad band. Accordingly, a circularly polarizing plate using such a quarter wavelength plate cannot perfectly perform the function of circularly polarizing plate over the whole visible light range. For example, therefore, when a quarter wavelength plate for green light at 550 nm is used, it will be difficult to completely prevent the reflection of longer wavelength light such as red light or shorter wavelength light such as blue light. Particularly, blue light with relatively large dispersion can cause relatively large retardation shift and thus can cause a problem in which reflected color can be tinged with blue.

[0004]

Means for overcoming the wavelength dependence of such a quarter wavelength plate is proposed in which a laminated wavelength plate comprising a laminate of two retardation plates different in retardation is used to form a quarter wavelength plate (See Japanese Patent Application Laid-Open(JP A) Nos. 05-27118 and 05-100114). In the quarter wavelength plate using such a laminated wavelength plate, the wavelength dependence of retardation can be overcome so that the quarter wavelength plate function can be performed over the whole visible wavelength range. A quarter wavelength plate comprising a laminate of a transparent support, a liquid crystal compound layer and a birefringent film layer is also known (see JP-A No. 13-4837).

[0005]

It is also proposed that a single piece of an oriented polymer film which has a smaller retardation at a shorter wavelength is used to form an quarter wavelength plate independent of wavelength over the visible wavelength range (see JP-A Nos. 2000-137116 and 2001-249222). It is also known that the birefringent properties of the retardation plate forming such a quarter wavelength plate are controlled in three-dimensional directions so that the properties of a circularly polarizing plate can be conserved at wide viewing angles (see JP-A Nos. 2001-91743 and 2003-332068).

[0006]

Dichroic absorbing polarizers such as iodine based polarizers comprising stretched polyvinyl alcohol on which iodine is adsorbed

are widely used, because they have high transmittances and high degrees of polarization (see JP-A No. 2001-296427). However, iodine based polarizers have relatively low degrees of polarization on the short wavelength side and thus have a problem with hue, such as blue dropout on the short wavelength side during black viewing and yellowing during white viewing.

[0007]

Iodine based polarizers can also easily suffer from uneven iodine adsorption. Such unevenness can be detected as uneven transmittance particularly during black viewing and cause the problem of a reduction in visibility. In order to solve the problem, for example, there are proposed a method in which the amount of iodine adsorbed on iodine based polarizer is increased such that the transmittance for black viewing does not exceed the lower limit of sensitivity of human eyes and a method employing a stretching process that is resistant to causing unevenness itself. However, the former method has a problem in which the transmittance for white viewing is also reduced in the same way as the transmittance for black viewing so that display itself becomes dark. The latter method also has a problem in which a certain process has to be entirely replaced so that the productivity can be reduced.

[0008]

In particular, an application using a circularly polarizing plate as a transmission filter such as above-mentioned circularly polarizing mode multidomain panel, the circularly polarizing plate is

required to have a higher transmittance and a higher degree of polarization, therefore a problem in which the above-mentioned unevenness is more significantly observed.

Disclosure of Invention

[0009]

It is an object of the invention to provide a circularly polarizing plate which includes a laminate of an absorbing polarizer and a quarter wavelength plate and has a wide viewing angle, a high contrast, a high transmittance, and a high degree of polarization and in which uneven transmittance can be suppressed when black viewing is displayed.

[0010]

It is another object of the invention to provide an optical film using at least one piece of the circularly polarizing plate and to provide an image display using the circularly polarizing plate or the optical film.

[0011]

As a result of examination wholeheartedly performed by the present inventors that the above-mentioned subject should be solved, it was found out that the above-mentioned purpose might be attained using a circularly polarizing plates shown below, leading to completion of this invention.

[0012]

That is, this invention relates to a circularly polarizing plate

comprising:

a complex type scattering-dichroic absorbing polarizer including a film that has a structure having a minute domain dispersed in a matrix formed of an optically-transparent water-soluble resin including an iodine based light absorbing material; and

a quarter wavelength plate formed with one or more retardation plates.

[0013]

The minute domain of the complex type absorbing polarizer is preferably formed by an oriented birefringent material. The above-mentioned birefringent material preferably shows liquid crystallinity at least in orientation processing step.

[0014]

The above-mentioned polarizer of this invention has an iodine based polarizer formed by an optically-transparent water-soluble resin and an iodine based light absorbing material as a matrix, and has dispersed minute domains in the above-mentioned matrix. Minute domains are preferably formed by oriented materials having birefringence, and particularly minute domains are formed preferably with materials showing liquid crystallinity. Thus, in addition to function of absorption dichroism by iodine based light absorbing materials, characteristics of having function of scattering anisotropy improve polarization performance according to synergistic effect

of the two functions, and as a result a polarizer having both of transmittance and polarization degree, and excellent visibility may be provided.

[0015]

Scattering performance of anisotropic scattering originates in refractive index difference between matrixes and minute domains. For example, if materials forming minute domains are liquid crystalline materials, since they have higher wavelength dispersion of Δn compared with optically-transparent water-soluble resins as a matrix, a refractive index difference in scattering axis becomes larger in shorter wavelength side, and, as a result, it provides more amounts of scattering in shorter wavelength. Accordingly, an improving effect of large polarization performance is realized in shorter wavelengths, compensating a relative low level of polarization performance of an iodine based polarizer in a side of shorter wavelength, and thus a polarizer having high polarization and neutral hue may be realized.

[0016]

A combination of the complex type scattering-dichroic absorbing polarizer, the quarter wavelength plate provides a circularly polarizing plate with optical compensation function that has a high transmittance and a high degree of polarization, can produce high contrast in a wide viewing angle range, and can suppress unevenness in transmittance during black viewing.

[0017]

In the above-mentioned circularly polarizing plate, it is preferable that the minute domains of the complex type absorbing polarizer have a birefringence of 0.02 or more. In materials used for minute domains, in the view point of gaining larger anisotropic scattering function, materials having the above-mentioned birefringence may be preferably used.

[0018]

In the above-mentioned circularly polarizing plate, in a refractive index difference between the birefringent material forming the minute domains and the optically-transparent water-soluble resin of the complex type absorbing polarizer in each optical axis direction, a refractive index difference (Δn^1) in direction of axis showing a maximum is 0.03 or more, and a refractive index difference (Δn^2) between the Δn^1 direction and a direction of axes of two directions perpendicular to the Δn^1 direction is 50% or less of the Δn^1

[0019]

Control of the above-mentioned refractive index difference (Δn^1) and (Δn^2) in each optical axis direction into the above-mentioned range may provide a scattering anisotropic film having function being able to selectively scatter only linearly polarized light in the Δn^1 direction, as is submitted in U.S. Pat. No. 2123902 specification. That is, on one hand, having a large refractive index difference in the Δn^1 direction, it may scatter

linearly polarized light, and on the other hand, having a small refractive index difference in the Δn^2 direction, and it may transmit linearly polarized light. Moreover, refractive index differences (Δn^2) in the directions of axes of two directions perpendicular to the Δn^1 direction are preferably equal.

[0020]

In order to obtain high scattering anisotropy, a refractive index difference (Δn^1) in a Δn^1 direction is set 0.03 or more, preferably 0.05 or more, and still preferably 0.10 or more. A refractive index difference (Δn^2) in two directions perpendicular to the Δn^1 direction is 50% or less of the above-mentioned Δn^1, and preferably 30% or less.

[0021]

In iodine based light absorbing material in the above-mentioned circularly polarizing plate, a an absorption axis of the iodine based light absorbing material of the complex type absorbing polarizer is preferably orientated in the Δn^1 direction.

[0022]

The iodine based light absorbing material in a matrix is orientated so that an absorption axis of the material may become parallel to the above-mentioned Δn^1 direction, and thereby linearly polarized light in the Δn^1 direction as a scattering polarizing direction may be selectively absorbed. As a result, on one hand, a linearly polarized light component of incident light in a Δn^2 direction is not scattered or hardly absorbed by the iodine

based light absorbing material as in conventional iodine based polarizers without anisotropic scattering performance. On the other hand, a linearly polarized light component in the Δn^1 direction is scattered, and is absorbed by the iodine based light absorbing material. Usually, absorption is determined by an absorption coefficient and a thickness. In such a case, scattering of light greatly lengthens an optical path length compared with a case where scattering is not given. As a result, polarized component in the Δn^1 direction is more absorbed as compared with a case in conventional iodine based polarizers. That is, higher polarization degrees may be attained with same transmittances.

[0023]

Descriptions for ideal models will, hereinafter, be given. Two main transmittances usually used for linear polarizer (a first main transmittance k_1 (a maximum transmission direction = linearly polarized light transmittance in a Δn^2 direction), a second main transmittance k_2 (a minimum transmission direction = linearly polarized light transmittance in a Δn^1 direction)) are, hereinafter, used to give discussion.

[0024]

In commercially available iodine based polarizers, when iodine based light absorbing materials are oriented in one direction, a parallel transmittance and a polarization degree may be represented as follows, respectively:

parallel transmittance = 0.5 x $((k_1)^2 + (k_2)^2)$ and

polarization degree = $(k_1 - k_2) / (k_1 + k_2)$.

[0025]

On the other hand, when it is assumed that, in a polarizer of this invention, a polarized light in a Δn^1 direction is scattered and an average optical path length is increased by a factor of α (> 1), and depolarization by scattering may be ignored, main transmittances in this case may be represented as k_1 and $k_2' = 10^x$ (where, x is $\alpha \log k_2$), respectively

[0026]

That is, a parallel transmittance in this case and the polarization degree are represented as follows:

parallel transmittance = 0.5 x $((k_1)^2 + (k_2')^2)$ and

polarization degree = $(k_1 - k_2') / (k_1 + k_2')$.

[0027]

When a polarizer of this invention is prepared by a same condition (an amount of dyeing and production procedure are same) as in commercially available iodine based polarizers (parallel transmittance 0.385, polarization degree 0.965: k_1 = 0.877, k_2 = 0.016), on calculation, when α is 2 times, k_2 becomes small reaching 0.0003, and as result, a polarization degree improves up to 0.999, while a parallel transmittance is maintained as 0.385. The above-mentioned result is on calculation, and function may decrease a little by effect of depolarization caused by scattering, surface reflection,

backscattering, etc. As the above-mentioned equations show, higher value α may give better results and higher dichroic ratio of the iodine based light absorbing material may provide higher function. In order to obtain higher value α, a highest possible scattering anisotropy function may be realized and polarized light in a Δn^1 direction may just be selectively and strongly scattered. Besides, less backscattering is preferable, and a ratio of backscattering strength to incident light strength is preferably 30% or less, and more preferably 20% or less.

[0028]

In the above-mentioned circularly polarizing plate, the films used as the complex type absorbing polarizer manufactured by stretching may suitably be used.

[0029]

In the above-mentioned circularly polarizing plate, minute domains of the complex type absorbing polarizer preferably have a length in a Δn^2 direction of 0.05 to 500 μm.

[0030]

In order to scatter strongly linearly polarized light having a plane of vibration in a Δn^1 direction in wavelengths of visible light band, dispersed minute domains have a length controlled to 0.05 to 500 μm in a Δn^2 direction, and preferably controlled to 0.5 to 100 μm. When the length in the Δn^2 direction of the minute domains is too short a compared with wavelengths, scattering may not fully provided. On the other hand, when the length in

the Δn^2 direction of the minute domains is too long, there is a possibility that a problem of decrease in film strength or of liquid crystalline material forming minute domains not fully oriented in the minute domains may arise.

[0031]

In the above-mentioned circularly polarizing plate, the retardation plate forming the quarter wavelength plate can be made of a stretched film of a transparent polymer film and/or a layer of an aligned and solidified liquid-crystalline compound.

[0032]

In the above-mentioned circularly polarizing plate, at least one of the retardation plates forming the quarter wavelength plate preferably satisfies the formula: $0<(nx-nz)/(nx-ny)<1$, where nx is a maximum in-plane refractive index, ny is a refractive index in a direction perpendicular to the direction in which the maximum in-plane refractive index is provided, and nz is a refractive index in the thickness direction.

[0033]

Because of anisotropic scattering, the complex type absorbing polarizer can be easily affected by obliquely incident light even at a viewing angle vertical to the front face. Thus, if the display element to be used is already optically compensated with any other retardation film or if the display element itself is used for optical compensation, the quarter wavelength plate for use in the circularly polarizing plate should preferably have a retardation of a

quarter wavelength at wide viewing angles by itself. Therefore, the quarter wavelength plate for use in the invention preferably has a retardation of a quarter wavelength at wide viewing angles. Specifically, at least one of the retardation plates that form the quarter wavelength plate preferably satisfies the formula: $0<(nx-nz)/(nx-ny)<1$, more preferably satisfies the formula: $0.2<(nx-nz)/(nx-ny)<0.8$. In particular, all the retardation plates that form the quarter wavelength plate preferably satisfy the requirement that $(nx-nz)/(nx-ny)$ be in the above range.

[0034]

In the above-mentioned circularly polarizing plate, the retardation plate forming the quarter wavelength plate preferably has reverse dispersion properties and satisfies the formula: $1.2<(nx-nz)/(nx-ny)<2.0$, where nx is a maximum in-plane refractive index, ny is a refractive index in a direction perpendicular to the direction in which the maximum in-plane refractive index is provided, and nz is a refractive index in the thickness direction.

[0035]

If the display element to be used is in multidomain VA liquid crystal mode or is not optically compensated with any other retardation film, a combination of a liquid crystal layer and the quarter wavelength plate for use in the circularly polarizing plate preferably have a retardation of a quarter wavelength at wide viewing angles. Specifically, the retardation plate that forms the quarter wavelength plate preferably has reverse dispersion

properties and preferably satisfies the formula: $1.2<(nx-nz)/(nx-ny)<2.0$.

[0036]

The complex type absorbing polarizer and the quarter wavelength plate are preferably laminated and fixed with a transparent acrylic pressure-sensitive adhesive. If the complex type absorbing polarizer and the quarter wavelength plate are only layered on each other, it would be difficult to form a solid laminate with no space therebetween. Thus, they are preferably bonded together with an optically-transparent adhesive or pressure-sensitive adhesive. The pressure-sensitive adhesive is preferred in terms of convenience of bonding, and an acrylic pressure-sensitive adhesive is preferred in terms of transparency, adhesive properties, weather resistance, and heat resistance.

[0037]

In the above-mentioned circularly polarizing plate, with regard to the complex type absorbing polarizer, a transmittance to a linearly polarized light in a transmission direction is 80% or more, a haze value is 5% or less, and a haze value to a linearly polarized light in an absorption direction is 30% or more.

[0038]

A complex type absorbing polarizer of this invention having the above-mentioned transmittance and haze value has a high transmittance and excellent visibility for linearly polarized light in a transmission direction, and has strong optical diffusibility for

linearly polarized light in an absorption direction. Therefore, without sacrificing other optical properties and using a simple method, it may demonstrate a high transmittance and a high polarization degree, and may control unevenness of the transmittance in the case of black viewing.

[0039]

As a complex type absorbing polarizer of this invention, a polarizer is preferable that has as high as possible transmittance to linearly polarized light in a transmission direction, that is, linearly polarized light in a direction perpendicular to a direction of maximal absorption of the above-mentioned iodine based light absorbing material, and that has 80% or more of light transmittance when an optical intensity of incident linearly polarized light is set to 100. The light transmittance is preferably 85% or more, and still preferably 88% or more. Here, a light transmittance is equivalent to a value Y calculated from a spectral transmittance in 380 nm to 780 nm measured using a spectrophotometer with an integrating sphere based on CIE 1931 XYZ standard colorimetric system. In addition, since about 8% to 10% is reflected by an air interface on a front surface and rear surface of a polarizer, an ideal limit is a value in which a part for this surface reflection is deducted from 100%.

[0040]

It is desirable that a complex type absorbing polarizer does not scatter linearly polarized light in a transmission direction in

the view point of obtaining clear visibility of a display image. Accordingly, the polarizer preferably has 5% or less of haze value to the linearly polarized light in the transmission direction, more preferably 3% or less. On the other hand, in the view point of covering unevenness by a local transmittance variation by scattering, a polarizer desirably scatters strongly linearly polarized light in a absorption direction, that is, linearly polarized light in a direction for a maximal absorption of the above-mentioned iodine based light absorbing material. Accordingly, a haze value to the linearly polarized light in the absorption direction is preferably 30% or more, more preferably 40% or more, and still more preferably 50% or more. In addition, the haze value here is measured based on JIS K 7136 (how to obtain a haze of plastics-transparent material).

[0041]

The above-mentioned optical properties are obtained by compounding a function of scattering anisotropy with a function of an absorption dichroism of the polarizer. As is indicated in U.S. Pat. No. 2123902 specification, Japanese Patent Laid-Open No.9-274108, and Japanese Patent Laid-Open No.9-297204, same characteristics may probably be attained also in a way that a scattering anisotropic film having a function to selectively scatter only linearly polarized light, and a dichroism absorption type polarizer are superimposed in an axial arrangement so that an axis providing a greatest scattering and an axis providing a

greatest absorption may be parallel to each other. These methods, however, require necessity for separate formation of a scattering anisotropic film, have a problem of precision in axial joint in case of superposition, and furthermore, a simple superposition method does not provide increase in effect of the above-mentioned optical path length of the polarized light absorbed as is expected, and as a result, the method cannot easily attain a high transmission and a high polarization degree.

[0042]

This invention also relates to an optical film comprising at least one of the above-mentioned circularly polarizing plate.

[0043]

This invention further relates to an image display comprising the above-mentioned circularly polarizing plate or the above-mentioned optical film.

Brief Description of Drawing

[0044]

Fig. 1 is a schematic diagram showing an example of the polarizer according to the invention; and

Fig. 2 is a graph showing the polarized absorption spectra of the polarizers in Example 1 and Comparative Example 1.

Best Mode for Carrying Out the Invention

[0046]

The optical film of the invention includes: a complex type scattering-dichroic absorbing polarizer and a quarter wavelength plate are laminated.

[0047]

A complex type scattering-dichroic absorbing polarizer of this invention will, hereinafter, be described referring to drawings. Fig. 1 is a conceptual view of a complex type absorbing polarizer of this invention, and the polarizer has a structure where a film is formed with an optically-transparent water-soluble resin 1 including an iodine based light absorbing material 2, and minute domains 3 are dispersed in the film concerned as a matrix. As described above, the complex type absorbing polarizer according to the invention includes the iodine based light-absorbing material 2 preferentially in the optically-transparent thermoplastic resin 1, which forms the film serving as a matrix. However, the iodine based light-absorbing material 2 may also be allowed to exist in the minute domains 3 as long as it will have no optical effect.

[0048]

Fig. 1 shows an example of a case where the iodine based light absorbing material 2 is oriented in a direction of axis (Δn^1 direction) in which a refractive index difference between the minute domain 3 and the optically-transparent water-soluble resin 1 shows a maximal value. In minute domain 3, a polarized component in the Δn^1 direction is scattered. In Fig. 1, the Δn^1 direction in one direction in a film plane is an absorption axis.

In the film plane, a Δn^2 direction perpendicular to the Δn^1 direction serves as a transmission axis. Another Δn^2 direction perpendicular to the Δn^1 direction is a thickness direction.

[0049]

As optically-transparent water-soluble resins 1, resins having optically- transparency in a visible light band and dispersing and absorbing the iodine based light absorbing materials may be used without particular limitation. For example, polyvinyl alcohols or derivatives thereof conventionally used for polarizers may be mentioned. As derivatives of polyvinyl alcohol, polyvinyl formals, polyvinyl acetals, etc. may be mentioned, and in addition derivatives modified with olefins, such as ethylene and propylene, and unsaturated carboxylic acids, such as acrylic acid, methacrylic acid, and crotonic acid, alkyl esters of unsaturated carboxylic acids, acrylamides etc. may be mentioned. Besides, as optically-transparent water-soluble resin 1, for example, polyvinyl pyrrolidone based resins, amylose based resins, etc. may be mentioned. The above-mentioned optically-transparent water-soluble resin may be of resins having isotropy not easily generating orientation birefringence caused by molding deformation etc., and of resins having anisotropy easily generating orientation birefringence.

[0050]

Examples of the optically-transparent resin 1 also include polyester resins such as polyethylene terephthalate and

polyethylene naphthalate; styrene resins such as polystyrene and acrylonitrile-styrene copolymers (AS resins); and olefin resins such as polyethylene, polypropylene, cyclo type- or norbornene structure-containing polyolefins, and olefin based resins such as ethylene-propylene copolymers. Examples thereof also include vinyl chloride resins, cellulose resins, acrylic resins, amide resins, imide resins, sulfone polymers, polyethersulfone resins, polyetheretherketone resin polymers, polyphenylene sulfide resins, vinylidene chloride resins, vinyl butyral resins, arylate resins, polyoxymethylene resins, silicone resins, and urethane resins. One or more of these resins may be used either individually or in any combination. Any cured material of a thermosetting or ultraviolet-curable type resins such as a phenol based, melamine based, acrylic based, urethane, acrylic-urethane based, epoxy based, or silicone based resin may also be used.

[0051]

In materials forming minute domains 3, it is not limited whether the material has birefringence or isotropy, but materials having birefringence is particularly preferable. Moreover, as materials having birefringence, materials (henceforth, referred to as liquid crystalline material) showing liquid crystallinity at least at the time of orientation treatment may preferably used. That is, the liquid crystalline material may show or may lose liquid crystallinity in the formed minute domain 3, as long as it shows liquid crystallinity at the orientation treatment time.

[0052]

As materials forming minute domains 3, materials having birefringences (liquid crystalline materials) may be any of materials showing nematic liquid crystallinity, smectic liquid crystallinity, and cholesteric liquid crystallinity, or of materials showing lyotropic liquid crystallinity. Moreover, materials having birefringence may be of liquid crystalline thermoplastic resins, and may be formed by polymerization of liquid crystalline monomers. When the liquid crystalline material is of liquid crystalline thermoplastic resins, in the view point of heat-resistance of structures finally obtained, resins with high glass transition temperatures may be preferable. Furthermore, it is preferable to use materials showing glass state at least at room temperatures. Usually, a liquid crystalline thermoplastic resin is oriented by heating, subsequently cooled to be fixed, and forms minute domains 3 while liquid crystallinity are maintained. Although liquid crystalline monomers after orienting can form minute domains 3 in the state of fixed by polymerization, cross-linking, etc., some of the formed minute domains 3 may lose liquid crystallinity.

[0053]

As the above-mentioned liquid crystalline thermoplastic resins, polymers having various skeletons of principal chain types, side chain types, or compounded types thereof may be used without particular limitation. As principal chain type liquid

crystal polymers, polymers, such as condensed polymers having structures where mesogen groups including aromatic units etc. are combined, for example, polyester based, polyamide based, polycarbonate based, and polyester imide based polymers, may be mentioned. As the above-mentioned aromatic units used as mesogen groups, phenyl based, biphenyl based, and naphthalene based units may be mentioned, and the aromatic units may have substituents, such as cyano groups, alkyl groups, alkoxy groups, and halogen groups.

[0054]

As side chain type liquid crystal polymers, polymers having principal chain of, such as polyacrylate based, polymethacrylate based, poly-alpha-halo acrylate based, poly-alpha-halo cyano acrylate based, polyacrylamide based, polysiloxane based, and poly malonate based principal chain as a skeleton, and having mesogen groups including cyclic units etc. in side chains may be mentioned. As the above-mentioned cyclic units used as mesogen groups, biphenyl based, phenyl benzoate based, phenylcyclohexane based, azoxybenzene based, azomethine based, azobenzene based, phenyl pyrimidine based, diphenyl acetylene based, diphenyl benzoate based, bicyclo hexane based, cyclohexylbenzene based, terphenyl based units, etc. may be mentioned. Terminal groups of these cyclic units may have substituents, such as cyano group, alkyl group, alkenyl group, alkoxy group, halogen group, haloalkyl group, haloalkoxy group,

and haloalkenyl group. Groups having halogen groups may be used for phenyl groups of mesogen groups.

[0055]

Besides, any mesogen groups of the liquid crystal polymer may be bonded via a spacer part giving flexibility. As spacer parts, polymethylene chain, polyoxymethylene chain, etc. may be mentioned. A number of repetitions of structural units forming the spacer parts is suitably determined by chemical structure of mesogen parts, and the number of repeating units of polymethylene chain is 0 to 20, preferably 2 to 12, and the number of repeating units of polyoxymethylene chain is 0 to 10, and preferably 1 to 3.

[0056]

The above-mentioned liquid crystalline thermoplastic resins preferably have glass transition temperatures of 50°C or more, and more preferably 80°C or more. Furthermore they have approximately 2,000 to 100,000 of weight average molecular weight.

[0057]

As liquid crystalline monomers, monomers having polymerizable functional groups, such as acryloyl groups and methacryloyl groups, at terminal groups, and further having mesogen groups and spacer parts including the above-mentioned cyclic units etc. may be mentioned. Crossed-linked structures may be introduced using polymerizable functional groups having

two or more acryloyl groups, methacryloyl groups, etc., and durability may also be improved.

[0058]

Materials forming minute domains 3 are not entirely limited to the above-mentioned liquid crystalline materials, and non-liquid crystalline resins may be used if they are different materials from the matrix materials. As the above-mentioned resins, polyvinyl alcohols and derivatives thereof, polyolefins, polyarylates, polymethacrylates, polyacrylamides, polyethylene terephthalates, acrylic styrene copolymes, etc. may be mentioned. Moreover, particles without birefringence may be used as materials for forming the minute domains 3. As fine-particles concerned, resins, such as polyacrylates and acrylic styrene copolymers, may be mentioned. A size of the fine-particles is not especially limited, and particle diameters of 0.05 to 500 μm may be used, and preferably 0.5 to 100 μm. Although it is preferable that materials for forming minute domains 3 is of the above-mentioned liquid crystalline materials, non-liquid crystalline materials may be mixed and used to the above-mentioned liquid crystalline materials. Furthermore, as materials for forming minute domains 3, non-liquid crystalline materials may also be independently used.

[0059]

Iodine based light absorbing material means chemical species comprising iodine and absorbs visible light, and it is

thought that, in general, they are formed by interaction between optically-transparent water-soluble resins (particularly polyvinyl alcohol based resins) and poly iodine ions (I_3^-, I_5^-, etc.). An iodine based light absorbing material is also called an iodine complex. It is thought that poly iodine ions are generated from iodine and iodide ions.

[0060]

Iodine based light absorbing materials having an absorption band at least in a wavelength range of 400 to 700nm is preferably used.

[0061]

Examples of the absorbing dichroic material for use as an alternative to the iodine based light absorbing material include absorbing dichroic dyes, absorbing dichroic pigments and the like. In the invention, iodine based light-absorbing materials are preferably used as the absorbing dichroic material. In the case where the optically-transparent resin 1 used as the matrix material is a water-soluble resin such as polyvinyl alcohol, iodine based light-absorbing materials are particularly preferred in terms of high degree of polarization and high transmittance.

[0062]

Preferably used are absorbing dichroic dyes that have heat resistance and do not lose their dichroism by decomposition or degradation even when the birefringent liquid-crystalline material is aligned by heating. As described above, the absorbing dichroic dye

preferably has at least one absorption band with a dichroic ratio of at least 3 in the visible wavelength range. In the evaluation of the dichroic ratio, for example, an appropriate liquid crystal material containing a dissolved dye is used to form a homogeneously aligned liquid crystal cell, and the cell is measured for a polarized absorption spectrum, in which the absorption dichroic ratio at the absorption maximum wavelength is used as an index for evaluating the dichroic ratio. In this evaluation method, E-7 manufactured by Merck & Co. may be used as a standard liquid crystal. In this case, the dye to be used should generally have a dichroic ratio of at least about 3, preferably of at least about 6, more preferably of at least about 9, at the absorption wavelength.

[0063]

Examples of the dye having such a high dichroic ratio include azo dyes, perylene dyes and anthraquinone dyes, which are preferably used for dye polarizers. Any of these dyes may be used in the form of a mixed dye. For example, these dyes are described in detail in JP-A No. 54-76171.

[0064]

In the case where a color polarizer is produced, a dye having an absorption wavelength appropriate to the properties of the polarizer may be used. In the case where a neutral gray polarizer is produced, two or more types of dyes may be appropriately mixed such that absorption can occur over the whole visible light range.

[0065]

In a complex type scattering-dichroic absorbing polarizer of this invention, while producing a film in which a matrix is formed with an optically-transparent water-soluble resin 1 including an iodine based light absorbing material 2, minute domains 3 (for example, an oriented birefringent material formed with liquid crystalline materials) are dispersed in the matrix concerned. Moreover, the above-mentioned refractive index difference (Δn^1) in a Δn^1 direction and a refractive index difference (Δn^2) in a Δn^2 direction are controlled to be in the above-mentioned range in the film.

[0066]

Manufacturing process of a complex type absorbing polarizer of this invention is not especially limited, and for example, the polarizer of this invention may be obtained using following production processes:

(1) a process for manufacturing a mixed solution in which a material for forming minute domains is dispersed in an optically-transparent water-soluble resin forming a matrix (description is, hereinafter, to be provided, with reference to an example of representation, for a case where a liquid crystalline material is used as a material forming the minute domains. A case by a liquid crystalline material will apply to a case by other materials.);

(2) a process in which a film is formed with the mixed solution of the above-mentioned (1);

(3) a process in which the film obtained in the above-mentioned (2) is oriented (stretched); and

(4) a process in which an iodine based light absorbing material is dispersed (dyed) in the optically-transparent water-soluble resin forming the above-mentioned matrix.

In addition, an order of the processes (1) to (4) may suitably be determined.

[0067]

In the above-mentioned process (1), a mixed solution is firstly prepared in which a liquid crystalline material forming minute domains is dispersed in an optically-transparent water-soluble resin forming a matrix. A method for preparing the mixed solution concerned is not especially limited, and a method may be mentioned of utilizing a phase separation phenomenon between the above-mentioned matrix component (an optically-transparent water-soluble resin) and a liquid crystalline material. For example, a method may be mentioned in which a material having poor compatibility between the matrix component as a liquid crystalline material is selected, a solution of the material forming the liquid crystalline material is dispersed using dispersing agents, such as a surface active agent, in a water solution of the matrix component. In preparation of the above-mentioned mixed solution, some of combinations of the optically-transparent material forming the matrix, and the liquid crystal material forming minute domains do not require a

dispersing agent. An amount used of the liquid crystalline material dispersed in the matrix is not especially limited, and a liquid crystalline material is 0.01 to 100 parts by weight to an optically-transparent water-soluble resin 100 parts by weight, and preferably it is 0.1 to 10 parts by weight. The liquid crystalline material is used in a state dissolved or not dissolved in a solvent. Examples of solvents, for example, include: water, toluene, xylene, hexane cyclohexane, dichloromethane, trichloromethane, dichloroethane, trichloroethane, tetrachloroethane, trichloroethylene, methyl ethyl ketone, methylisobutylketone, cyclohexanone, cyclopentanone, tetrahydrofuran, ethyl acetate, etc. Solvents for the matrix components and solvents for the liquid crystalline materials may be of same, or may be of different solvents.

[0068]

In the above-mentioned process (2), in order to reduce foaming in a drying process after a film formation, it is desirable that solvents for dissolving the liquid crystalline material forming minute domains is not used in preparation of the mixed solution in the process (1). When solvents are not used, for example, a method may be mentioned in which a liquid crystalline material is directly added to an aqueous solution of an optically-transparency material forming a matrix, and then is heated above a liquid crystal temperature range in order to disperse the liquid crystalline material uniformly in a smaller state.

[0069]

In addition, a solution of a matrix component, a solution of a liquid crystalline material, or a mixed solution may include various kinds of additives, such as dispersing agents, surface active agents, ultraviolet absorption agents, flame retardants, antioxidants, plasticizers, mold lubricants, other lubricants, and colorants in a range not disturbing an object of this invention.

[0070]

In the process (2) for obtaining a film of the above-mentioned mixed solution, the above-mentioned mixed solution is heated and dried to remove solvents, and thus a film with minute domains dispersed in the matrix is produced. As methods for formation of the film, various kinds of methods, such as casting methods, extrusion methods, injection molding methods, roll molding methods, and flow casting molding methods, may be adopted. In film molding, a size of minute domains in the film is controlled to be in a range of 0.05 to 500 μm in a Δn^2 direction. Sizes and dispersibility of the minute domains may be controlled, by adjusting a viscosity of the mixed solution, selection and combination of the solvent of the mixed solution, dispersant, and thermal processes (cooling rate) of the mixed solvent and a rate of drying. For example, a mixed solution of an optically-transparent water-soluble resin that has a high viscosity and generates high shearing force and that forms a matrix, and a liquid crystalline material forming minute domains

is dispersed by agitators, such as a homogeneous mixer, being heated at a temperature in no less than a range of a liquid crystal temperature, and thereby minute domains may be dispersed in a smaller state.

[0071]

The process (3) giving orientation to the above-mentioned film may be performed by stretching the film. In stretching, uniaxial stretching, biaxial stretching, diagonal stretching are exemplified, but uniaxial stretching is usually performed. Any of dries type stretching in air and wet type stretching in an aqueous system bath may be adopted as the stretching method. When adopting a wet type stretching, an aqueous system bath may include suitable additives (boron compounds, such as boric acid; iodide of alkali metal, etc.) A stretching ratio is not especially limited, and in usual a ratio of approximately 2 to 10 times is preferably adopted.

[0072]

This stretching may orient the iodine based light absorbing material in a direction of stretching axis. Moreover, the liquid crystalline material forming a birefringent material is oriented in the stretching direction in minute domains by the above-mentioned stretching, and as a result birefringence is demonstrated.

[0073]

It is desirable the minute domains may be deformed

according to stretching. When minute domains are of non-liquid crystalline materials, approximate temperatures of glass transition temperatures of the resins are desirably selected as stretching temperatures, and when the minute domains are of liquid crystalline materials, temperatures making the liquid crystalline materials exist in a liquid crystal state such as nematic phase or smectic phase or an isotropic phase state, are desirably selected as stretching temperatures. When inadequate orientation is given by stretching process, processes, such as heating orientation treatment, may separately be added.

[0074]

In addition to the above-mentioned stretching, function of external fields, such as electric field and magnetic field, may be used for orientation of the liquid crystalline material. Moreover, liquid crystalline materials mixed with light reactive substances, such as azobenzene, and liquid crystalline materials having light reactive groups, such as a cinnamoyl group, introduced thereto are used, and thereby these materials may be oriented by orientation processing with light irradiation etc. Furthermore, a stretching processing and the above-mentioned orientation processing may also be used in combination. When the liquid crystalline material is of liquid crystalline thermoplastic resins, it is oriented at the time of stretching, cooled at room temperatures, and thereby orientation is fixed and stabilized. Since target optical property will be demonstrated if orientation is carried out,

the liquid crystalline monomer may not necessarily be in a cured state. However, in liquid crystalline monomers having low isotropic transition temperatures, a few temperature rise provides an isotropic state. In such a case, since anisotropic scattering may not be demonstrated but conversely polarized light performance deteriorates, the liquid crystalline monomers are preferably cured. Besides, many of liquid crystalline monomers will be crystallized when left at room temperatures, and then they will demonstrate anisotropic scattering and polarized light performance conversely deteriorate, the liquid crystalline monomers are preferably cured. In the view point of these phenomena, in order to make orientation state stably exist under any kind of conditions, liquid crystalline monomers are preferably cured. In curing of a liquid crystalline monomer, for example, after the liquid crystalline monomer is mixed with photopolymerization initiators, dispersed in a solution of a matrix component and oriented, in either of timing (before dyed or after dyed by iodine based light absorbing materials), the liquid crystalline monomer is cured by exposure with ultraviolet radiation etc. to stabilize orientation. Desirably, the liquid crystalline monomer is cured before dyed with iodine based light absorbing materials.

[0075]

As a process (4) in which the iodine based light absorbing material is dispersed in the optically-transparent water-soluble

resin used for forming the above-mentioned matrix, in general, a method in which the above-mentioned film is immersed into a bath of aqueous system including iodine dissolved with auxiliary agents of iodide of alkali metals, such as potassium iodide may be mentioned. As mentioned above, an iodine based light absorbing material is formed by interaction between iodine dispersed in the matrix and the matrix resin. Timing of immersing may be before or after the above-mentioned stretching process (3). The iodine based light absorbing material is, in general, remarkably formed by being passed through a stretching process. A concentration of the aqueous system bath including iodine, and a percentage of the auxiliary agents, such as iodide of alkali metals may not especially be limited, but general iodine dyeing techniques may be adopted, and the above-mentioned concentration etc. may arbitrarily be changed.

[0076]

Moreover, a percentage of the iodine in the polarizer obtained is not especially limited, but a percentage of the optically-transparent water-soluble resin and the iodine are preferably controlled so that the iodine is 0.05 to 50 parts by weight grade to the optically-transparent water-soluble resin 100 parts by weight, and more preferably 0.1 to 10 parts by weight.

[0077]

In a case the absorbing dichroic dye is used as the absorbing dichroic material, a percentage of the absorbing dichroic dye in the

polarizer obtained is not especially limited, but a percentage of the optically-transparent thermoplastic resin and the absorbing dichroic dye is preferably so that the absorbing dichroic dye is controlled to be 0.01 to 100 parts by weight grade to the optically-transparent thermoplastic resin 100 parts by weight, and more preferably 0.05 to 50 parts by weight.

[0078]

In production of the complex type absorbing polarizer, processes for various purposes (5) may be given other than the above-mentioned processes (1) to (4). As a process (5), for example, a process in which a film is immersed in water bath and swollen may be mentioned for the purpose of mainly improving iodine dyeing efficiency of the film. Besides, a process in which a film is immersed in a water bath including arbitrary additives dissolved therein may be mentioned. A process in which a film is immersed in an aqueous solution including additives, such as boric acid and borax, for the purpose of cross-linking a water-soluble resin (matrix) may be mentioned. Moreover, for the purpose of mainly adjusting an amount balance of the dispersed iodine based light absorbing materials, and adjusting a hue, a process in which a film is immersed to an aqueous solution including additives, such as an iodide of an alkaline metals may be mentioned.

[0079]

As for the process (3) of orienting (stretching) of the

above-mentioned film, the process (4) of dispersing and dyeing the iodine based light absorbing material to a matrix resin and the above-mentioned process (5), so long as each of the processes (3) and (4) is provided at least 1 time, respectively, a number, order and conditions (a bath temperature, immersion period of time, etc.) of the processes, may arbitrarily be selected, each process may separately be performed and furthermore a plurality of processes may simultaneously be performed. For example, a cross-linking process of the process (5) and the stretching process (3) may be carried out simultaneously.

[0080]

In addition, although the iodine based light absorbing material used for dyeing, boric acid used for cross-linking are permeated into a film by immersing the film in an aqueous solution as mentioned above, instead of this method, a method may be adopted that arbitrary types and amounts may be added before film formation of the process (2) and before or after preparation of a mixed solution in the process (1). And both methods may be used in combination. However, when high temperatures (for example, no less than 80°C) is required in the process (3) at the time of stretching etc., in the view point of heat resistance of the iodine based light absorbing material, the process (4) for dispersing and dyeing the iodine based light absorbing material may be desirably performed after the process (3).

[0081]

A film given the above treatments is desirably dried using suitable conditions. Drying is performed according to conventional methods.

[0082]

A thickness of the obtained polarizer (film) is not especially limited, in general, but it is 1 μm to 3 mm, preferably 5 μm to 1 mm, and more preferably 10 to 500 μm.

[0083]

A polarizer obtained in this way does not especially have a relationship in size between a refractive index of the birefringent material forming minute domains and a refractive index of the matrix resin in a stretching direction, whose stretching direction is in a Δn^1 direction and two directions perpendicular to a stretching axis are Δn^2 directions. Moreover, the stretching direction of an iodine based light absorbing material is in a direction demonstrating maximal absorption, and thus a polarizer having a maximally demonstrated effect of absorption and scattering may be realized.

[0084]

The above-described polarizer may be used as a polarizing plate with a transparent protective layer prepared at least on one side thereof using a usual method. The transparent protective layer may be prepared as an application layer by polymers, or a laminated layer of films. Proper transparent materials may be used

as a transparent polymer or a film material that forms the transparent protective layer, and the material having outstanding transparency, mechanical strength, heat stability and outstanding moisture interception property, etc. may be preferably used. As materials of the above-mentioned protective layer, for example, polyester type polymers, such as polyethylene terephthalate and polyethylenenaphthalate; cellulose type polymers, such as diacetyl cellulose and triacetyl cellulose; acrylics type polymer, such as poly methylmethacrylate; styrene type polymers, such as polystyrene and acrylonitrile-styrene copolymer (AS resin); polycarbonate type polymer may be mentioned. Besides, as examples of the polymer forming a protective film, polyolefin type polymers, such as polyethylene, polypropylene, polyolefin that has cyclo- type or norbornene structure, ethylene-propylene copolymer; vinyl chloride type polymer; amide type polymers, such as nylon and aromatic polyamide; imide type polymers; sulfone type polymers; polyether sulfone type polymers; polyether-ether ketone type polymers; poly phenylene sulfide type polymers; vinyl alcohol type polymer; vinylidene chloride type polymers; vinyl butyral type polymers; arylate type polymers; polyoxymethylene type polymers; epoxy type polymers; or blend polymers of the above-mentioned polymers may be mentioned. Films made of heat curing type or ultraviolet ray curing type resins, such as acryl based, urethane based, acryl urethane based, epoxy based, and silicone based, etc. may be mentioned.

[0085]

Moreover, as is described in Japanese Patent Laid-Open Publication No. 2001-343529 (WO 01/37007), polymer films, for example, resin compositions including (A) thermoplastic resins having substituted and/or non-substituted imido group is in side chain, and (B) thermoplastic resins having substituted and/or non-substituted phenyl and nitrile group in sidechain may be mentioned. As an illustrative example, a film may be mentioned that is made of a resin composition including alternating copolymer comprising iso-butylene and N-methyl maleimide, and acrylonitrile-styrene copolymer. A film comprising mixture extruded article of resin compositions etc. may be used.

[0086]

As a transparent protection film, if polarization property and durability are taken into consideration, cellulose based polymer, such as triacetyl cellulose, is preferable, and especially triacetyl cellulose film is suitable. In general, a thickness of a transparent protection film is 500 μm or less, preferably 1 to 300 μm, and especially preferably 5 to 300 μm. In addition, when transparent protection films are provided on both sides of the polarizer, transparent protection films comprising same polymer material may be used on both of a front side and a back side, and transparent protection films comprising different polymer materials etc. may be used.

[0087]

Moreover, it is preferable that the protection film may have as little coloring as possible. Accordingly, a protection film having a retardation value in a film thickness direction represented by Rth= [(nx+ny) /2 - nz] x d of -90 nm to +75 nm (where, nx and ny represent principal indices of refraction in a film plane, nz represents refractive index in a film thickness direction, and d represents a film thickness) may be preferably used. Thus, coloring (optical coloring) of polarizing plate resulting from a protection film may mostly be cancelled using a protection film having a retardation value (Rth) of -90 nm to +75 nm in a thickness direction. The retardation value (Rth) in a thickness direction is preferably -80 nm to +60 nm, and especially preferably -70 nm to +45 nm.

[0088]

A hard coat layer may be prepared, or antireflection processing, processing aiming at sticking prevention, diffusion or anti glare may be performed onto the face on which the polarizer of the above described transparent protective film has not been adhered.

[0089]

A hard coat processing is applied for the purpose of protecting the surface of the polarizing plate from damage, and this hard coat film may be formed by a method in which, for example, a curable coated film with excellent hardness, slide property etc. is added on the surface of the protective film using suitable ultraviolet curable type resins, such as acrylic type and

silicone type resins. Antireflection processing is applied for the purpose of antireflection of outdoor daylight on the surface of a polarizing plate and it may be prepared by forming an antireflection film according to the conventional method etc. Besides, a sticking prevention processing is applied for the purpose of adherence prevention with adjoining layer.

[0090]

In addition, an anti glare processing is applied in order to prevent a disadvantage that outdoor daylight reflects on the surface of a polarizing plate to disturb visual recognition of transmitting light through the polarizing plate, and the processing may be applied, for example, by giving a fine concavo-convex structure to a surface of the protective film using, for example, a suitable method, such as rough surfacing treatment method by sandblasting or embossing and a method of combining transparent fine particle. As a fine particle combined in order to form a fine concavo-convex structure on the above-mentioned surface, transparent fine particles whose average particle size is 0.5 to 50 μm, for example, such as inorganic type fine particles that may have conductivity comprising silica, alumina, titania, zirconia, tin oxides, indium oxides, cadmium oxides, antimony oxides, etc., and organic type fine particles comprising cross-linked of non-cross-linked polymers may be used. When forming fine concavo-convex structure on the surface, the amount of fine particle used is usually about 2 to 50 weight parts to the

transparent resin 100 weight parts that forms the fine concavo-convex structure on the surface, and preferably 5 to 25 weight parts. An anti glare layer may serve as a diffusion layer (viewing angle expanding function etc.) for diffusing transmitting light through the polarizing plate and expanding a viewing angle etc.

[0091]

In addition, the above-mentioned antireflection layer, sticking prevention layer, diffusion layer, anti glare layer, etc. may be built in the protective film itself, and also they may be prepared as an optical layer different from the protective layer.

[0092]

Adhesives are used for adhesion processing of the above described polarizer and the transparent protective film. As adhesives, isocyanate derived adhesives, polyvinyl alcohol derived adhesives, gelatin derived adhesives, vinyl polymers derived latex type, aqueous polyesters derived adhesives, etc. may be mentioned. The above-described adhesives are usually used as adhesives comprising aqueous solution, and usually contain solid of 0.5 to 60 % by weight.

[0093]

A polarizing plate of the present invention is manufactured by adhering the above described transparent protective film and the polarizer using the above described adhesives. The application of adhesives may be performed to any of the transparent protective

film or the polarizer, and may be performed to both of them. After adhered, drying process is given and the adhesion layer comprising applied dry layer is formed. Adhering process of the polarizer and the transparent protective film may be performed using a roll laminator etc. Although a thickness of the adhesion layer is not especially limited, it is usually approximately 0.1 to 5 μm.

[0094]

The circularly polarizing plate of the invention is a combination of a complex type absorbing polarizer (which may be laminated with the protective film or the like to form a complex type absorbing polarizing plate) and a quarter wavelength plate.

[0095]

The retardation plate for forming the quarter wavelength plate may be made of a transparent stretched (oriented) polymer film or a layer of an aligned and solidified liquid-crystalline compound. The thickness of the retardation plate is preferably, but not limited to, from about 0.5 to 500 μm.

[0096]

Examples of the polymer film material include polycarbonate, polyvinyl alcohol, polystyrene, polymethyl methacrylate, polypropylene and other polyolefins, polyarylate, polyamide, polyester, polysulfone, polyethersulfone, cellulose acetate, and polyvinyl chloride. The stretched film may be produced by uniaxially or biaxially stretching a polymer film. The stretched film whose refractive index is controlled in the thickness direction may

be prepared by a process including the steps of bonding a heat-shrinkable film to a polymer film and then subjecting the polymer film to a stretching process and/or a shrinking process under the action of the contractile force by heating.

[0097]

Examples of the layer of the aligned and solidified liquid-crystalline compound include an aligned liquid crystal polymer film and an aligned liquid crystal polymer layer supported on a transparent film. Examples thereof also include tilt aligned liquid crystal polymers whose refractive indices are controlled in the thickness direction.

[0098]

The quarter wavelength plate may comprise a single piece of a retardation plate having a retardation of a quarter wavelength or may be a laminated wavelength plate comprising two or more pieces of retardation plates that are laminated so as to provide controlled optical properties and provide a retardation of a quarter wavelength. The laminated wavelength plate can function as a quarter wavelength plate with a small dependence of its retardation on wavelength in a relatively wide wavelength range such as the visible light range. For example, the laminated wavelength plate may be produced by laminating a retardation plate that functions as a quarter wavelength plate for monochromatic light and another retardation plate having other retardation properties, such as a retardation plate that functions as a half wavelength plate. The

laminated wavelength plate may also be produced by a process including the steps of using two or more pieces of retardation plates that function as quarter wavelength plates for monochromatic light and laminating them in such a manner that their axial angles are controlled so as to produce a retardation of a quarter wavelength.

[0099]

A retardation plate having reverse dispersion properties is preferably used as the quarter wavelength plate. The retardation plate having reverse dispersion properties has a smaller retardation at a shorter wavelength. The retardation plate having reverse dispersion properties may be an oriented film of a blend polymer composed of a polymer having positive refractive index anisotropy and another polymer having negative refractive index anisotropy or may be an oriented film of a copolymer composed of monomer units for polymers having positive and negative refractive index anisotropies, respectively. For example, the retardation plate having such reverse dispersion properties is preferably made of a combination of a bisphenol compound having positive optical anisotropy and a fluorene ring-containing bisphenol compound having negative optical anisotropy as disclosed in JP-A No. 2003-315550. The retardation plate may also be an oriented film of a cellulose film with a specific degree of acetylation as disclosed in JP-A No. 2000-137116.

[0100]

While the complex type absorbing polarizer (or the complex

type absorbing polarizing plate) and a quarter wavelength plate may be only stacked to form the circularly polarizing plate of the invention, they are preferably laminated with no air space left between them by the use of an adhesive or pressure-sensitive adhesive, in terms of workability or light use efficiency.

[0101]

The adhesive and the pressure-sensitive adhesive are not especially limited. For example, acrylic type polymers; silicone type polymers; polyesters, polyurethanes, polyamides, polyethers; fluorine type and rubber type polymers, such as natural rubber, synthetic rubber may be suitably selected as a base polymer. Especially, the adhesive and the pressure-sensitive may be preferably used, which is excellent in optical transparency, showing adhesion characteristics with moderate wettability, cohesiveness and adhesive property and has outstanding weather resistance, heat resistance, etc.

[0102]

The adhesive or the pressure-sensitive adhesive preferably has no absorption in the visible light range and preferably has a refractive index as close as possible to the refractive index of each layer in terms of suppressing surface reflection. In this point of view, for example, acrylic pressure-sensitive adhesives are preferably used.

[0103]

The adhesive or the pressure-sensitive adhesive may contain

any crosslinking agent appropriate to the base polymer. The adhesive layer may contain additives, for example, such as natural or synthetic resins, adhesive resins, glass fibers, glass beads, metal powder, fillers comprising other inorganic powder etc., pigments, colorants and antioxidants. Moreover, it may be an adhesive layer that contains fine particle and shows optical diffusion nature.

[0104]

In addition, in the present invention, ultraviolet absorbing property may be given to the above-mentioned each layer, such as an optical film etc. and a pressure-sensitive adhesive layer, using a method of adding UV absorbents, such as salicylic acid ester type compounds, benzophenol type compounds, benzotriazol type compounds, cyano acrylate type compounds, and nickel complex salt type compounds.

[0105]

The adhesive or the pressure-sensitive adhesive is generally used in the form of an adhesive solution with a solids content of about 10 to about 50% by weight, in which the base polymer or a composition thereof is dissolved or dispersed in a solvent. Any appropriate solvent such as water and an organic solvent such as toluene and ethyl acetate may be selected and used depending on the type of the adhesive.

[0106]

The adhesive layer and the pressure-sensitive adhesive layer

may also be prepared on one side or both sides of the polarizing plate or the optical film as a layer in which pressure-sensitive adhesives with different composition or different kind etc. are laminated together. Thickness of the pressure-sensitive adhesive layer may be suitably determined depending on a purpose of usage or adhesive strength, etc., and generally is 1 to 500 μm, preferably 5 to 200 μm, and more preferably 10 to 100 μm.

[0107]

An adhesive layer and a pressure-sensitive adhesive layer may be prepared on the circularly polarizing plate. The pressure-sensitive adhesive layer is used for adhesion with a liquid crystal cell, and lamination other optical layers. When the optical films are bonded, their optical axes may be set at appropriate angles depending on the desired retardation properties.

[0108]

A temporary separator is attached to an exposed side of an pressure-sensitive adhesive layer to prevent contamination etc., until it is practically used. Thereby, it can be prevented that foreign matter contacts pressure-sensitive adhesive layer in usual handling. As a separator, without taking the above-mentioned thickness conditions into consideration, for example, suitable conventional sheet materials that is coated, if necessary, with release agents, such as silicone type, long chain alkyl type, fluorine type release agents, and molybdenum sulfide may be used. As a suitable sheet material, plastics films, rubber sheets, papers,

cloths, no woven fabrics, nets, foamed sheets and metallic foils or laminated sheets thereof may be used.

[0109]

The circularly polarizing plate of the invention may be used for a liquid crystal display in a conventional manner. The liquid crystal display may include a liquid crystal cell, polarizing plates placed on both sides of the liquid crystal cell, and any of various types of optical layers and the like. The above-mentioned circularly polarizing plate or the optical film is used on at least one side of the liquid crystal cell. The liquid crystal display may be formed in a conventional manner. Specifically, a general liquid crystal display may be formed by assembling a liquid crystal cell, optical elements, and optional components such as a lighting system in an appropriate manner and incorporating a driving circuit and the like, while any conventional techniques may be used except that the optical film of the invention is used. The liquid crystal cell may be of any type such as TN type, STN type and π type.

[0110]

Additionally, any other appropriate components such as a diffusing plate, an antiglare layer, an antireflection film, a protective plate, a prism array, a lens array sheet, a light diffusion plate, and a backlight may also be placed in one or more layers at appropriate positions to form a liquid crystal display.

[0111]

While the above-mentioned circularly polarizing plate or the

optical film may be formed by independently and sequentially laminating the components in the process of manufacturing a liquid crystal display or the like, the circularly polarizing plate or the optical film formed by pre-lamination has the advantages that it has stable quality and good assembling workability and can improve the process of manufacturing liquid crystal displays or the like. The lamination may be performed using any appropriate adhesive means such as a pressure-sensitive adhesive layer. In the process of bonding the circularly polarizing plate or any other optical film, their optical axes may be arranged so as to make an appropriate angles depending on the desired retardation properties.

[0112]

Although there is especially no limitation about the optical layers to be laminated in practical use, one layer or two layers or more of optical layers, which may be used for formation of a liquid crystal display etc., such as a reflector, a transflective plate, and a viewing angle compensation film, may be used. A brightness enhancement film is also used to laminate.

[0113]

A reflective layer is prepared on a polarizing plate to give a reflection type polarizing plate, and this type of plate is used for a liquid crystal display in which an incident light from a view side (display side) is reflected to give a display. This type of plate does not require built-in light sources, such as a backlight, but has an advantage that a liquid crystal display may easily be made

thinner. A reflection type polarizing plate may be formed using suitable methods, such as a method in which a reflective layer of metal etc. is, if required, attached to one side of a polarizing plate through a transparent protective layer etc.

[0114]

In addition, a transflective type polarizing plate may be obtained by preparing the above-mentioned reflective layer as a transflective type reflective layer, such as a half-mirror etc. that reflects and transmits light. A transflective type polarizing plate is usually prepared in the backside of a liquid crystal cell and it may form a liquid crystal display unit of a type in which a picture is displayed by an incident light reflected from a view side (display side) when used in a comparatively well-lighted atmosphere. And this unit displays a picture, in a comparatively dark atmosphere, using embedded type light sources, such as a back light built in backside of a transflective type polarizing plate. That is, the transflective type polarizing plate is useful to obtain of a liquid crystal display of the type that saves energy of light sources, such as a back light, in a well-lighted atmosphere, and can be used with a built-in light source if needed in a comparatively dark atmosphere etc.

[0115]

A viewing angle compensation film is a film for extending viewing angle so that a picture may look comparatively clearly, even when it is viewed from an oblique direction not from vertical

direction to a screen. As such viewing angle compensation retardation plate, in addition, a film having birefringence property that is processed by uniaxial stretching or orthogonal bidirectional stretching and a biaxially stretched film as inclined orientation film etc. may be used. As inclined orientation film, for example, a film obtained using a method in which a heat shrinking film is adhered to a polymer film, and then the combined film is heated and stretched or shrunk under a condition of being influenced by a shrinking force, or a film that is oriented in oblique direction may be mentioned. The viewing angle compensation film is suitably combined for the purpose of prevention of coloring caused by change of visible angle based on retardation by liquid crystal cell etc. and of expansion of viewing angle with good visibility.

[0116]

Besides, a compensation plate in which an optical anisotropy layer consisting of an alignment layer of liquid crystal polymer, especially consisting of an inclined alignment layer of discotic liquid crystal polymer is supported with triacetyl cellulose film may preferably be used from a viewpoint of attaining a wide viewing angle with good visibility.

[0117]

The polarizing plate with which a polarizing plate and a brightness enhancement film are adhered together is usually used being prepared in a backside of a liquid crystal cell. A brightness

enhancement film shows a characteristic that reflects linearly polarized light with a predetermined polarization axis, or circularly polarized light with a predetermined direction, and that transmits other light, when natural light by back lights of a liquid crystal display or by reflection from a back-side etc., comes in. The polarizing plate, which is obtained by laminating a brightness enhancement film to a polarizing plate, thus does not transmit light without the predetermined polarization state and reflects it, while obtaining transmitted light with the predetermined polarization state by accepting a light from light sources, such as a backlight. This polarizing plate makes the light reflected by the brightness enhancement film further reversed through the reflective layer prepared in the backside and forces the light re-enter into the brightness enhancement film, and increases the quantity of the transmitted light through the brightness enhancement film by transmitting a part or all of the light as light with the predetermined polarization state. The polarizing plate simultaneously supplies polarized light that is difficult to be absorbed in a polarizer, and increases the quantity of the light usable for a liquid crystal picture display etc., and as a result luminosity may be improved.

[0118]

The suitable films are used as the above-mentioned brightness enhancement film. Namely, multilayer thin film of a dielectric substance; a laminated film that has the characteristics

of transmitting a linearly polarized light with a predetermined polarizing axis, and of reflecting other light, such as the multilayer laminated film of the thin film having a different refractive-index anisotropy; an aligned film of cholesteric liquid-crystal polymer; a film that has the characteristics of reflecting a circularly polarized light with either left-handed or right-handed rotation and transmitting other light, such as a film on which the aligned cholesteric liquid crystal layer is supported; etc. may be mentioned.

[0119]

Moreover, the polarizing plate may consist of multi-layered film of laminated layers of a polarizing plate and two of more of optical layers as the above-mentioned separated type polarizing plate. Therefore, a polarizing plate may be a reflection type elliptically polarizing plate or a semi-transmission type elliptically polarizing plate, etc. in which the above-mentioned reflection type polarizing plate or a transflective type polarizing plate is combined with above described retardation plate respectively.

[0120]

Subsequently, organic electro luminescence equipment (organic EL display) will be explained. Generally, in organic EL display, a transparent electrode, an organic luminescence layer and a metal electrode are laminated on a transparent substrate in an order configuring an illuminant (organic electro luminescence illuminant). Here, an organic luminescence layer is a laminated

material of various organic thin films, and much compositions with various combination are known, for example, a laminated material of hole injection layer comprising triphenylamine derivatives etc., a luminescence layer comprising fluorescent organic solids, such as anthracene; a laminated material of electronic injection layer comprising such a luminescence layer and perylene derivatives, etc.; laminated material of these hole injection layers, luminescence layer, and electronic injection layer etc.

[0121]

In an organic EL display containing an organic electro luminescence illuminant equipped with a transparent electrode on a surface side of an organic luminescence layer that emits light by impression of voltage, and at the same time equipped with a metal electrode on a back side of organic luminescence layer, a retardation plate may be installed between these transparent electrodes and a polarizing plate, while preparing the polarizing plate on the surface side of the transparent electrode.

[0122]

Since the retardation plate and the polarizing plate have function polarizing the light that has entered as incident light from outside and has been reflected by the metal electrode, they have an effect of making the mirror surface of metal electrode not visible from outside by the polarization action. If a retardation plate is configured with a quarter wavelength plate and the angle

between the two polarization directions of the polarizing plate and the retardation plate is adjusted to π/4, the mirror surface of the metal electrode may be completely covered.

[0123]

This means that only linearly polarized light component of the external light that enters as incident light into this organic EL display is transmitted with the work of polarizing plate. This linearly polarized light generally gives an elliptically polarized light by the retardation plate, and especially the retardation plate is a quarter wavelength plate, and moreover when the angle between the two polarization directions of the polarizing plate and the retardation plate is adjusted to π/4, it gives a circularly polarized light.

[0124]

This circularly polarized light is transmitted through the transparent substrate, the transparent electrode and the organic thin film, and is reflected by the metal electrode, and then is transmitted through the organic thin film, the transparent electrode and the transparent substrate again, and is turned into a linearly polarized light again with the retardation plate. And since this linearly polarized light lies at right angles to the polarization direction of the polarizing plate, it cannot be transmitted through the polarizing plate. As the result, mirror surface of the metal electrode may be completely covered.

Examples

[0125]

Examples of this invention will, hereinafter, be shown, and specific descriptions will be provided. In addition, "parts" in following sections represents parts by weight.

[0126]

Example 1

<Preparation of Complex Type Scattering-Dichroic Absorbing Polarizing Plate >

(Complex Type Scattering-Dichroic Absorbing Polarizer)

A polyvinyl alcohol aqueous solution with a solid matter content of 13 weight % in which a polyvinyl alcohol resin with a polymerization degree of 2400 and a saponification degree of 98.5 %, a liquid crystalline monomer (a nematic liquid crystal temperature is in the range of from 40 to 70°) having an acryloyl group at each of both terminals of a mesogen group and glycerin were mixed together so that a ratio of polyvinyl alcohol: a liquid crystalline monomer: glycerin = 100: 5: 15 (in weight ratio) and the mixture was heated to a temperature equal to or higher than a liquid crystal temperature range and agitated with a homomixer to thereby obtain a mixed solution. Bubbles existing in the mixed solution were defoamed by leaving the solution at room temperature (23°c) as it was, thereafter, the solution is coated by means of a casting method, subsequently thereto, and the wet coat was dried and to thereafter obtains a whitened mixed film with a thickness of 70 μm. The

mixed film was heat-treated at 130°C for 10 min.

[0127]

The mixed film was immersed in a water bath at 30°C and swollen, thereafter, the swollen film was stretched about three times while being immersed in an aqueous solution of iodine and potassium iodide in a ratio of 1 to 7 in weight (a dyeing bath, with a concentration of 0.32 weight %) at 30°C, thereafter the stretched film was further stretched to a total stretch magnification of being about six times while being immersed in a 3 weight % boric acid aqueous solution (crosslinking bath) at 50°C, followed by immersing further the stretched film in 4 weight % boric acid aqueous solution (crosslinking bath) at 50°C. Then, hue adjustment was conducted by immersing the film in 5 weight % potassium iodide aqueous solution bath at 30°C. Subsequent thereto, the film was dried at 50°C for 4 minutes to obtain a polarizer of the present invention.

[0128]

(Confirmation of Generation of Anisotropic Scattering and Measurement of Refractive Index)

The obtained polarizer was observed under a polarization microscope and it was able to be confirmed that numberless dispersed minute domains of a liquid crystalline monomer were formed in a polyvinyl alcohol matrix. The liquid crystalline monomer is oriented in a stretching direction and an average size of minute domains in the stretching direction (Δn^1 direction) was in the range of from 5 to 10 μm. And an average size of minute

domains in a direction perpendicular to the stretching direction (Δn^2 direction) was in the range of from 0.5 to 3 μm.

[0129]

Refractive indices of the matrix and the minute domain were separately measured. Measurement was conducted at 20°C. A refractive index of a stretched film constituted only of a polyvinyl alcohol film stretched in the same conditions as the wet stretching was measured with an Abbe's refractometer (measurement light wavelength with 589 nm) to obtain a refractive index in the stretching direction (Δn^1 direction) = 1.54 and a refractive index in Δn^2 direction = 1.52. Refractive indexes (n_e: an extraordinary light refractive index and n_o: an ordinary light refractive index) of a liquid crystalline monomer were measured. An ordinary light refractive index n_o was measured of the liquid crystalline monomer orientation-coated on a high refractive index glass which is vertical alignment-treated with an Abbe's refractometer (measurement light with 589 nm). On the other hand, the liquid crystalline monomer is injected into a liquid crystal cell which is homogenous alignment-treated and a retardation (Δn x d) was measured with an automatic birefringence measurement instrument (automatic birefringence meter KOBRA21ADH) manufactured by Ohoji Keisokuki K.K.) and a cell gap (d) was measured separately with an optical interference method to calculate Δn from retardation/cell gap and to obtain the sum of Δn and n_o as n_e. An extraordinary light refractive index n_e (corresponding to a refractive index in the

Δn^1 direction) = 1.64 and n_0 (corresponding to a refractive index of Δn^2 direction) = 1.52. Therefore, calculation was resulted in Δn^1 = 1.64 – 1.52 = 0.10 and Δn^2 = 1.52 – 1.52 = 0.00. It was confirmed from the measurement described above that a desired anisotropic scattering was able to occur.

[0130]

(Polarizing Plate)

Triacetylcellulose films (each with a thickness of 80 μm) were laminated with a polyurethane adhesive on both sides of the complex type absorbing polarizer to form a complex type absorbing polarizing plate.

[0131]

<Preparation of Retardation Plates>

Hereinafter, the (nx-nz)/(nx-ny) value of the retardation plate is represented by Nz. Retardations and Nz were measured using Spectroscopic Ellipsometer M-220 manufactured by JASCO Corporation, and the incidence angle-dependence of the retardation of each sample was measured to determine three-dimensional refractive indices. In this process, a refractive index spheroid was assumed with respect to the refractive index anisotropy of each sample. The average refractive index necessary for calculation was separately measured with respect to light with a wavelength of 589 nm using an Abbe refractometer, and the measured average refractive index was used.

[0132]

(Retardation Plate 1)

A 50 μm-thick polycarbonate film was stretched at 150°C in the presence of a heat-shrinkable film that was adhered to the polycarbonate film, so that a half wavelength plate was prepared which had an Nz of 0.5 and a retardation of a half wavelength with respect to light with a wavelength of 550 nm.

[0133]

(Retardation Plate 2)

A 50 μm-thick polycarbonate film was stretched at 150°C to form a half wavelength plate having an Nz of 1 (namely ny=nz) and a retardation of a half wavelength with respect to light with a wavelength of 550 nm.

[0134]

(Retardation Plate 3)

A 50 μm-thick polycarbonate film was stretched at 150°C to form a quarter wavelength plate having an Nz of 1 and a retardation of a quarter wavelength with respect to light with a wavelength of 550 nm.

[0135]

(Retardation Plate 4)

A 100 μm-thick cyclic polyolefin film (ARTON manufactured by JSR Corporation) was stretched at 175°C in the presence of a heat-shrinkable film that was adhered to the cyclic polyolefin film, so that a quarter wavelength plate was prepared which had an Nz of 0.7 and a retardation of a quarter wavelength with respect to light

with a wavelength of 550 nm.

[0136]

(Retardation Plate 5)

An aqueous solution of 0.5% by weight polyvinyl alcohol (500 in degree of polymerization, completely saponified, manufactured by Kuraray Co., Ltd.) was applied to a triacetylcellulose film (40 μm) and dried to form a coating with a post-drying thickness of 20 nm. The coating surface was then rubbed with a rubbing fabric (made of rayon) in a single direction so that an aligned film was prepared. A solution of 25 parts by weight of a commercially available photo-crosslinkable liquid crystal (UCL-001 (trade name) manufactured by Dainippon Ink and Chemicals, Incorporated) dissolved in 75 parts by weight of cyclohexanone was applied to the aligned film by spin coating. The coating was then heated at 130°C for one minute and then irradiated with ultraviolet light at room temperature in an atmosphere produced by rapid replacement with nitrogen so that the liquid crystal was nematically aligned and fixed. The resulting retardation plate had an Nz of 1 and a retardation of a quarter wavelength with respect to light at 550 nm.

[0137]

(Retardation Plate 6)

A cellulose acetate film with a degree of acetylation of 2.66 (110 μm in thickness) was prepared according to Example 1 in JP-A No. 2000-137116, and then biaxially stretched at 170°C, resulting in a retardation plate with reverse dispersion, which had a smaller

retardation at a shorter measurement wavelength. The resulting retardation plate had a retardation of a quarter wavelength at 550 nm and an Nz of 1.6.

[0138]

Example 1

The above complex type scattering-dichroic absorbing polarizing plate and Retardation Plate 3 (the quarter wavelength plate) were bonded together through an acrylic pressure-sensitive adhesive to form a circularly polarizing plate. In the adhering process, the stretching axes of the complex type absorbing polarizing plate and the quarter wavelength plate crossed each other at an angle of 45°.

[0139]

Example 2

A circularly polarizing plate was obtained using the process of Example 1 except that Retardation Plate 4 (the quarter wavelength plate) was used in place of Retardation Plate 3 (the quarter wavelength plate).

[0140]

A circularly polarizing plate was obtained using the process of Example 1 except that Retardation Plate 5 (the quarter wavelength plate) was used in place of Retardation Plate 3 (the quarter wavelength plate).

[0141]

A circularly polarizing plate was obtained using the process of

Example 1 except that Retardation Plate 6 (the quarter wavelength plate) was used in place of Retardation Plate 3 (the quarter wavelength plate).

[0142]

Example 5

The above complex type scattering-dichroic absorbing polarizing plate, Retardation Plate 1 (the half wavelength plate) and Retardation Plate No. 3 (the quarter wavelength plate) were adhered together with an acrylic pressure-sensitive adhesive to form a circularly polarizing plate. The complex type absorbing polarizing plate, the half wavelength plate and the quarter wavelength plate was adhered so that the stretching axis of the half wavelength plate was crossed at an angle of 17.5°with respect to the stretching axis of the complex type absorbing polarizing plate and the stretching axis of the quarter wavelength plate was crossed at an angle of 80°with respect to the stretching axis of the complex type absorbing polarizing plate.

[0143]

A circularly polarizing plate was obtained using the process of Example 1 except that Retardation Plate 2 (the half wavelength plate) was used in place of Retardation Plate 1 (the half wavelength plate).

[0144]

Comparative Example 1

A polarizer was prepared in the same manner as described

above, except that the liquid-crystalline monomer was not used in the preparation of the complex type scattering-dichroic absorbing polarizer. Using the resulting polarizer, a polarizing plate was prepared in the same manner as describe above. A circularly polarizing plate was also prepared using the process of Example 1, except that the resulting polarizing plate was alternatively used.

[0145]

(Evaluation)

Polarizing plates obtained in Example and Comparative example were measured for optical properties using a spectrophotometer with integrating sphere (manufactured by Hitachi Ltd. U-4100). Transmittance to each linearly polarized light was measured under conditions in which a completely polarized light obtained through Glan Thompson prism polarizer was set as 100%. Transmittance was calculated based on CIE 1931 standard colorimetric system, and is shown with Y value, for which relative spectral responsivity correction was carried out. Notation k_1 represents a transmittance of a linearly polarized light in a maximum transmittance direction, and k_2 represents a transmittance of a linearly polarized light perpendicular to the direction.

[0146]

A polarization degree P was calculated with an equation $P = \{(k_1 - k_2) / (k_1 + k_2)\} \times 100$. A transmittance T of a simple substance was calculated with an equation $T = (k_1 + k_2) / 2$.

[0147]

Furthermore, polarizers obtained in Example and Comparative example were measured for a polarized light absorption spectrum using a spectrophotometer (manufactured by Hitachi Ltd. U-4100) with Glan Thompson prism. Fig. 4 shows polarized light absorption spectra of polarizers obtained in Example and Comparative example. "MD polarized lights" in Fig. 2 (a) represent polarized light absorption spectra when a polarized light with a plane of vibration parallel to a stretching axis enters, and "TD polarized lights" in Fig. 2 (b) represent polarized light absorption spectra when a polarized light with a plane of vibration perpendicular to a stretching axis enters.

[0148]

In TD polarized lights (= transmission axis of polarizer), in visible range whole band, while absorbance of the polarizers in Example 1 and Comparative example 1 showed almost equal value, in MD polarized lights (= absorption of polarizer + scattering axis), absorbance in the polarizer of Example 1 exceeded absorbance of the polarizer in Comparative example 1 in shorter wavelength side. That is, the above-mentioned result shows that light polarizing performance of the polarizer in Example 1 exceeded performance of the polarizer in Comparative example 1 in a short wavelength side. Since all conditions, such as stretching and dyeing, are equivalent in Example 1 and Comparative example 1, it is thought that orientation of iodine based light absorbing materials is also

equivalent. Therefore, as mentioned above, a rise of absorbance in MD polarized light of the polarizer of Example 1 shows that light polarizing performance improved by an effect caused by an effect of anisotropic scattering having been added to absorption by iodine.

[0149]

In haze values, a haze value to a linearly polarized light in a maximum transmittance direction, and a haze value to a linearly polarized light in an absorption direction (a perpendicular direction). Measurement of a haze value was performed according to JIS K7136 (how to obtain a haze of plastics-transparent material), using a haze meter (manufactured by Murakami Color Research Institute HM-150). A commercially available polarizing plate (NPF-SEG1224DU manufactured by NITTO DENKO CORP.: 43% of simple substance transmittances, 99.96% of polarization degree) was arranged on a plane of incident side of a measurement light of a sample, and stretching directions of the commercially available polarizing plate and the sample (polarizer) were made to perpendicularly intersect, and a haze value was measured. However, since quantity of light at the time of rectangular crossing is less than limitations of sensitivity of a detecting element when a light source of the commercially available haze meter is used, light by a halogen lamp which has high optical intensity provided separately was made to enter with a help of an optical fiber device, thereby quantity of light was set

as inside of sensitivity of detection, and subsequently a shutter closing and opening motion was manually performed to obtain a haze value to be calculated.

[0150]

Table 1

	Transmittance of linearly polarized light (%)		Single substance transmittance (%)	Polarization degree (%)	haze value (%)	
	Maximum transmission direction (k_1)	Perpendicular direction (k_2)			Maximum transmission direction	Perpendicular direction
Example 1	87.00	0.035	43.53	99.92	1.8	82.0
Comparative Example 1	87.00	0.043	43.52	99.90	0.3	0.2

[0151]

Table 1 shows that the polarizing plate in each of the example and the comparative example has good polarization properties such as a high single substance transmittance and a high degree of polarization. In the example, the polarizing plate uses a polarizer having a structure that includes a matrix formed of an optically-transparent water-soluble resin containing an iodine based light-absorbing material and minute domains dispersed in the matrix. Thus, it is apparent that the haze value with respect to the transmittance in the perpendicular direction is higher in the example than in the comparative example where the polarizing plate uses a conventional polarizer and that the unevenness caused by uneven transmittance is concealed by scattering so that it cannot be detected in the example.

[0152]

The circularly polarizing plates of Examples and Comparative Example were each evaluated for contrast (brightness and coloration) and unevenness. The results are shown in Table 2.

[0153]

Contrast and unevenness were evaluated as follows. A circularly polarizing plate for producing reversely circularly polarized light was prepared (by laminating the wavelength plate in such a manner that the crossed-axes angle was shifted 90° from the angle in each of Examples and Comparative Example) and laminated on the circularly polarizing plate of each of Examples

and Comparative Example to form a sample in which the wavelength plate sides of them were placed inside. The sample was placed on the top face of a backlight for liquid crystal displays, and a light leak and unevenness were observed from vertically above the sample. The observation of a light leak was performed by measuring brightness (cd/cm^2) with BM-5 manufactured by Topcon Corporation. The degree of coloration and the amount of light were also visually checked. In the evaluation of unevenness, a level at which the unevenness was visually detectable was represented by the mark "×", while a level at which the unevenness was not visually detectable was represented by the mark "○".

[0154]

Table 2

Circularly Polarizing Plate	Contrast		Unevenness
	Brightness (cd/cm^2)	Coloration	
Example 1	1.2	Violet	○
Example 2	0.5	Blue-Violet	○
Example 3	1.7	Violet	○
Example 4	0.5	Black	○
Example 5	0.3	Black-Violet	○
Example 6	0.6	Black-Violet	○
Comparative Example 1	0.8	Violet	×

[0155]

The result of the above experiment assuming black viewing on a liquid crystal display element suggests that the unevenness caused by uneven transmittance is concealed by scattering so that it cannot be detected in each of Examples, while it can be detected

in Comparative Example (a conventional circularly polarizing plate). A comparison between Examples 1 and 2 or between Examples 5 and 6 also indicates that the light leak from the circularly polarizing plate is less in Example 2 or 5 due to the Nz coefficient effect. It is also apparent that the degree of coloration of light is lower in Example 4, 5 or 6, because the quarter wavelength plate of Example 4, 5 or 6 can work in a broader wavelength range.

[0156]

A commercially available polarizing plate for a VA mode liquid crystal panel was substituted for the circularly polarizing plate of Example 4 or Comparative Example 1 and implemented in the arrangement. The substituted portion had significantly increased brightness in both the example and the comparative example when white viewing was displayed. The level of the unevenness was checked when black viewing was displayed in a darkroom. As a result, the part in which the circularly polarizing plate of the example was implemented showed no detectable unevenness and exhibited very good visibility, in contrast to the part with the circularly polarizing plate of the comparative example. The part in which the circularly polarizing plate of the example was implemented also had good visibility at wide viewing angles.

[0157]

As a complex type scattering-dichroic absorbing polarizer having a similar structure as a structure of a polarizer of this

invention, a polarizer in which a mixed phase of a liquid crystalline birefringent material and an absorption dichroism material is dispersed in a resin matrix is disclosed in Japanese Patent Laid-Open No.2002-207118, whose effect is similar as that of this invention. However, as compared with a case where an absorption dichroism material exists in dispersed phase as in Japanese Patent Laid-Open No.2002-207118, since in a case where an absorption dichroism material exists in a matrix layer as in this invention a longer optical path length may be realized by which a scattered polarized light passes absorption layer, more scattered light may be absorbed. Therefore, this invention may demonstrate much higher effect of improvement in light polarizing performance. This invention may be realized with simple manufacturing process.

[0158]

Although an optical system to which a dichroic dye is added to either of continuous phase or dispersed phase is disclosed in Japanese Patent Laid-Open No.2000-506990, this invention has large special feature in a point of laminating a complex type absorbing polarizer and a quarter wavelength plate, especially this invention has large special feature in a point of using iodine as an absorption dichroism material of the complex type absorbing polarizer. The following advantages are realized when using not dichroic dye but iodine. (1) Absorption dichroism demonstrated with iodine is higher than by dichroic

dye. Therefore, polarized light characteristics will also become higher if iodine is used for a polarizer obtained. (2) Iodine does not show absorption dichroism, before being added in a continuous phase (matrix phase), and after being dispersed in a matrix, an iodine based light absorbing material showing dichroism is formed by stretching. This point is different from a dichroic dye having dichroism before being added in a continuous phase. That is, iodine exists as iodine itself, when dispersed in a matrix. In this case, in general, iodine has a far effective diffusibility in a matrix compared with a dichroic dye. As a result, iodine based light absorbing material is dispersed to all corners of a film more excellently than dichroic dye. Therefore, an effect of increasing optical path length by scattering anisotropy can be utilized for maximum, which increases polarized light function.

[0159]

A background of invention given in Japanese Patent Laid-Open No.2000-506990 describes that optical property of a stretched film in which liquid droplets of a liquid crystal are arranged in a polymer matrix is indicated by Aphonin et al. However, Aphonin et al. has mentioned an optical film comprising a matrix phase and a dispersed phase (liquid crystal component), without using a dichroic dye, and since a liquid crystal component is not a liquid crystal polymer or a polymerized liquid crystal monomer, a liquid crystal component

in the film concerned has a sensitive birefringence typically depending on temperatures. On the other hand, this invention provides a polarizer comprising a film having a structure where minute domains are dispersed in a matrix formed of an optically-transparent water-soluble resin including an iodine based light absorbing material, furthermore, in a liquid crystalline material of this invention, in the case of a liquid crystal polymer, after it is orientated in a liquid crystal temperature range, cooled to room temperatures and thus orientation is fixed, in the case of a liquid crystal monomer, similarly, after orientation, the orientation is fixed by ultraviolet curing etc., birefringence of minute domains formed by a liquid crystalline material does not change by the change of temperatures.

Industrial Applicability

[0160]

The circularly polarizing plate of the invention or the optical film using thereof is suitable for image displays such as liquid crystal displays, organic EL displays, CRTs, and PDPs.